A pragmatic utopia:

Should the Ross Sea be designated a Marine Protected Area??

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EXECUTIVE SUMMARY

The Ross Sea is a prominent embayment in the Antarctic continent, of around 650,000km^2 – an area equal to two percent of the Southern Ocean. Approximately two-thirds of this area is covered by the Ross Ice Shelf. The region is widely recognised as being the last ecosystem on Earth that is little affected by human interference. The Ross Sea is home to a plethora of unusual, unique and globally rare species; the area has high levels of biological diversity, productivity and endemism, all of which suggest the area is worth protecting.

Historically, there has been some exploitation of the seal and whale populations of the Ross Sea. More recently, the area has been subject to tourism, scientific whaling, and commercial fishing for the Antarctic toothfish. Of particular concern is the growing presence of fishing vessels taking part in illegal, unregulated and unreported (IUU) fishing activities. The Antarctic toothfish has life-history traits that make the species vulnerable to exploitation, and little is understood about its breeding biology. IUU fishing is worrisome because it represents an unknown level of extraction for a species that appears to hold a crucial position in the Ross Sea food web.

Marine Protected Areas (MPAs) have been gaining popularity worldwide as a management tool for protecting areas of special biological importance. Currently it is difficult to create and manage MPAs in areas beyond national jurisdiction – that is, the high seas – but for some areas, regional fisheries management organisations exists. The Southern Ocean is one such place, where the management falls under the auspices of CCAMLR, the Convention on the Conservation of Antarctic Marine Living Resources, and the associated Commission. CCAMLR successfully created the first ever high seas MPA in the Southern Ocean near the South Orkney Islands in 2010. We believe this sets an important precedent for what could be achieved in the Ross Sea.

This paper presents three possible plans for creating an MPA in the Ross Sea. Plan A would see the entire Ross Sea become a no-take area indefinitely. Plan B would create a network of MPA sub-areas within the Ross Sea. Plan C would create a management intervention in the form of a moratorium on all extractive resource use (fishing, whaling, bioprospecting) in the Ross Sea for 30 years. The role of CCAMLR and the relative merits of the three options are discussed.

Finally, some options are presented for how an MPA in the Ross Sea could be enforced. The Royal New Zealand Navy has boats suitable for enforcement work in the Southern Ocean; the Air Force already conducts surveillance activities, and the future acquisition of an unmanned drone is another possibility. However the most successful outcomes would be achieved via cooperative enforcement taken by a number of nations with interests in the Southern Ocean.

To conclude, the authors suggest protection of the Ross Sea is both feasible and warranted. The time to act is now.

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1. INTRODUCTION

1.1 Defining the Ross Sea

The Ross Sea (77^{o} S and 175^{o} W) is a large embayment at the edge of the Antarctic continent, extending from Cape Adare in the west to Cape Colbeck in the east (Waterhouse 2001). Roughly the size of Southern Europe, the Ross Sea has two key components: the continental shelf and continental slope (ASOC 2009). Mostly it is a broad continental shelf, 400-600m deep and covered by the 500,000km^{2} Ross Ice Shelf. The occasional shallow bank or deep trough makes for a range of unique sea floor features (Riffenburgh 2007).

1.2 Why the Ross Sea is unique

The Ross Sea is recognised as the last remaining ocean ecosystem little effected by human activity (ASOC 2009). It is home to an amazing array of creatures that form one of the most unique and complex marine ecosystems in the Antarctic (Dorey & Lütkebohle 2010). The Ross Sea's special features include a range of natural and physical characteristics, a diverse biota in both the neritic (coastal) and benthic (seafloor) realms, and an extremely high level of species endemism (Eastman 2005, Smith et al. 2007). The Ross Sea is home to the richest diversity of fishes in the Southern Ocean, including seven species found nowhere else in the world (ASOC 2009). The area also plays host to disproportionately large populations of seals, penguins, and whales, and has an evolutionary value comparable to that of the Galapagos Islands (Dorey & Lütkebohle 2010). The Ross Sea is interesting because the fish fauna is overwhelming dominated by a single family, the notothenioids; this group comprises 91% of the biomass and 77% of all fish species in the Ross Sea (Smith et al. 2007). Unlike all other portions of the world the top predators remain in large, healthy populations, and the relationships between the trophic levels, while incompletely characterised, appear to also remain relatively intact (Smith et al. 2007, ASOC 2009, Dorey & Lütkebohle 2010). Due to the lack of human influence on the Ross Sea environment, the area is invaluable to science. Acting as a 'living laboratory' the Ross Sea is the ideal place for investigating climate change and its impacts, and

for learning more about marine ecosystems without the influence from direct human impacts (Dorey & Lütkebohle 2010).

1.2.1 The Ross Sea Food Web

The Ross Sea has incredible biological diversity, abundant marine life, and a long history of human exploration and scientific research. The continental shelf of the Ross Sea is perhaps one of Antarctica's most intensively studied areas (ASOC 2009). Vast information can be found on the region's physical characteristics, yet in regards to the food web, much is known of each of the trophic levels yet many of the biological interactions are poorly understood and remain incomplete (Smith et al. 2007).

The lower trophic levels consist of phytoplankton and krill. Krill is intensely grazed by penguins, Antarctic silverfish, and minke whales who also feed on small fish. Two species of the notothenioid family are extremely important in the Ross Sea food web; the Antarctic silverfish, *Pleuragramma antarcticum* and the Antarctic toothfish *Dissostichus mawsoni* (Figure 1). *P. antarcticum* begins its life high in the water column but descends into the depths later in life. It feeds largely on zooplankton but is also opportunistic, ingesting other forms including amphipods and its own larvae. Antarctic toothfish, in turn, are prey to flying birds, penguins, minke *(Balaenoptera bonaerensis)* and killer whales (*Orcinus orca*), and Weddell Seals (*Leptonychotes weddellii*) (Figure 1). The Antarctic toothfish is the largest fish in Antarctic waters and is regarded as the polar equivalent of the shark (Ainley 2010a).

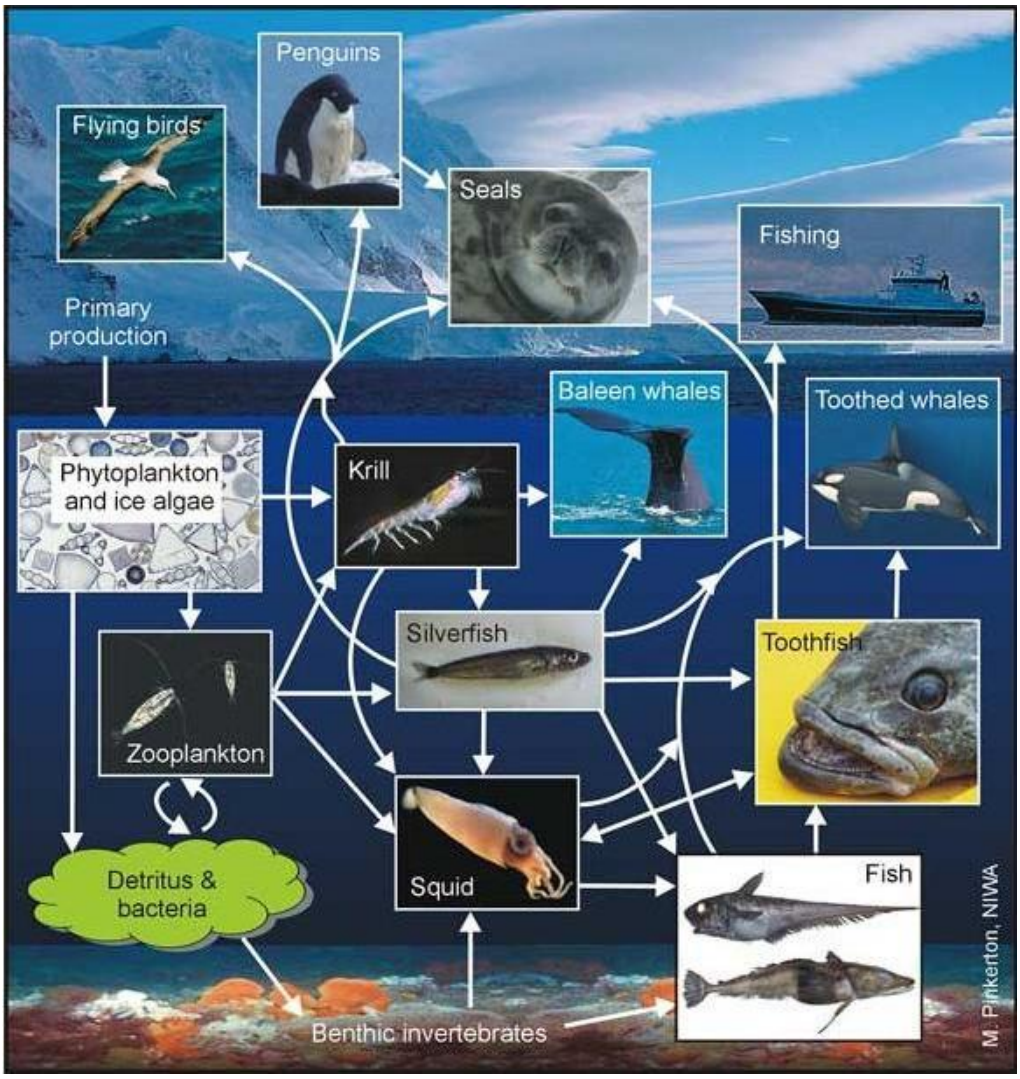

Figure 1. A simplified model of the Ross Sea food web (NIWA).

The Ross Sea food web appears to be significantly different from that of most other regions of the Southern Ocean; little is known about the effects of removing, or depleting, stocks within this food web (Smith et al. 2007).

Despite its remoteness, the Ross Sea has not been so lucky as to escape human use and exploitation completely.

2. EXPLOITATION IN THE ROSS SEA

2.1 Historical exploitation in the Ross Sea

Historical exploitation of resources in the Ross Sea has been limited to sealing, commercial whaling and more recently, fishing.

2.1.1 Sealing

Although sealing was the first industry in the Antarctic, there is no evidence of commercial sealing in the Ross Sea. An unknown number of Weddell seals were killed in the McMurdo Sound area for human and dog food during the 'heroic' era of Antarctic exploration (1901-1917). In the 1950s, the New Zealand Antarctic Programme killed approximately 200 Weddell seals from the vicinity of Scott Base for sledge dog food. Also, from 1957 to 1985, the US Antarctic Program killed an unknown number of seals for scientific purposes (Ainley 2010b)

The population of seals in McMurdo Sound has recovered slightly since the take of seals ended in the 1980s. The slow recovery for seal populations in the area are presumably a consequence of changes in the sea ice and, or, combined with changes in the food web (Ainley 2010). An example of this is the absence of elephant seals (*Mirounga leonina)* in the Ross Sea region since early 1980s. In recent tracking, individuals from Macquarie Island were foraging north of the Ross Sea, indicating poor availability or depletion of their fish prey in the area (Ainley & Blight 2009). Other species of seals, such as Leopard seal (*Hydrurga leptonyx)*, Crabeater (*Lobodon carcinophagus)* and Ross seal *(Ommatophoca rossii)* have never been exploited in the Ross Sea (Ainley 2010b)

2.1.2 Commercial whaling

Accounts of the early Antarctic explorers suggest the Ross Sea was abundant with whales. During the Nimrod expedition, Ernest Shackleton gave the name 'Bay of Whales' to a location in the Ross Sea, having encountered large concentrations of killer whales. Others, like Amundsen, sited large groups of killer whales in the same area. These clearly correspond to the diminutive type-C (fish eating) killer whale (Pitman et al. 2007), a sub-species unique to the Southern Ocean.

However the name Bay of Whales created confusion later, when commercial whaling began in the area around the 1920s. The expectation of the industry was to take large numbers of the great whales (blue, fin and sei whales) from the Ross Sea. Whaling occurred in the area from 1923 to 1930. A total of 11,680 whales were taken, 9,330 of those were blue whales (*B. musculus)* (Ainley 2010b). Minke whales were observed in abundance but at this time it was not a desirable species to catch. Whaling was supported by a factory ship stationed at the Ross Ice Shelf, and in later years the operations took place near Possession Island and the Balleny Islands.

More recently, whaling in the Ross Sea took place during the 1970s and 1980s. A total of 19,500 minke whales were taken off the coast of Adélie Land and the Ross Sea (Ainley 2010). As the great whales were almost depleted to extinction, the industry turned to the minkes, as the most abundant species in the Southern Ocean. The thought behind this decision was that in the absence of large competitors, the population of minke whales would have increased considerably. The size of the minke population before whaling is unknown (Ainley 2010b). Commercial whaling continued worldwide until an international moratorium ceased the activity in 1986.

2.1.3 Commercial fishing

In 1996 New Zealand initiated a programme of 'exploratory' fishing in the Ross Sea, targeting at Antarctic toothfish (*D. mawsoni)*. This is expanded upon in the following section.

2.2 Current exploitation in the Ross Sea

Currently, exploitation in the Ross Sea takes the form of fishing (both legal and illegal), tourism, private expeditions and extractive whaling for 'scientific' purposes.

2.2.1 Legal toothfish industry

In 1996, the New Zealand government began a programme of 'exploratory and scientific' longline fishery in the Ross Sea, targeting Antarctic toothfish and Patagonian toothfish (*D. eleginoides).* The goal of the programme is to fish the

population to 50% of its pre-exploitation biomass in 35 years (Blight et al. 2010). Soon after the programme began, other nations expressed interest on fishing in the Ross Sea and by 2000, fishing activities in the area were no longer truly exploratory but becoming industrial.

Fishing activities in Antarctic waters are under the management of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), an organization created by the Antarctic Treaty System (ATS). CCAMLR sets catch limits for target species in different areas of the Southern Ocean, establishes conservation measures to reduce the environmental impact of fishing, and grants access to vessels to fish in Antarctic waters. Within CCAMLR's jurisdiction, the Ross Sea is located in sub-areas 88.1 and 88.2 (CCAMLR 2010, Figure 2). For 2010/11 season, CCAMLR licensed 6 vessels from Korea, 3 from New Zealand, 4 from Russia, 1 from Spain, 2 from the UK and 1 from Uruguay. The species target by all these vessels is Patagonian and Antarctic toothfish (CCAMLR 2010).

Fishing vessels are committed to contribute with scientific research, such as tagging and releasing, biologically sampling fish, taking specimens, recording sightings of seabirds and other animals and monitoring sightings of other fishing vessels. The vessels carry two observers to monitor fishing practices (MFish 2010). The Ministry of Fisheries (MFish) sets strict conservation rules for operating vessels to avoid accidental by-catch of other species (such as seabirds), waste management and fitness of the vessels (MFish 2010). MFish also assists with the effective management of the fisheries with vessel inspections, patrolling the seas, and participating in scientific research and stock assessment.

CCAMLR bases the management of harvesting the Southern Ocean on 'the best available science, which indicates that the Ross Sea toothfish fishery is in very good health, and that it is being managed cautiously and effectively' (MFish 2010). However, respected polar scientists object this statement, arguing that there is no substantial data regarding the population dynamics of toothfish to support the scale of this industry in the Ross Sea. Key data missing are (Blight et al. 2010):

- identification of spawning areas
- eggs and larvae have never been found

- spawning intervals are unknown
- quantitative information about population of the species is poorly unknown

Also, the large adult toothfish targeted by the fishery are a key component of the food web of the Ross Sea. Removing 50% of spawning biomass of this slow growing species could have devastating effects in the ecosystem (Blight 2010).

2.2.2 Illegal, unregulated and unreported toothfish industry

Illegal fishing also occurs in the Southern Ocean and Ross Sea. Illegal, unregulated and unreported fishing, also known as IUU, is the most significant problem that CCAMLR has faced since the 1990s (Waterhouse 2001). Although efforts to patrol the area have been in place since the late 1990s, the Southern Ocean is a vast area to police effectively. Air patrols, navy vessels, cruise ships and non-governmental expeditions all assist with the identification of fishing vessels (Waterhouse 2001). The presence of an IUU fishery challenges CCAMLR conservation measures, affecting the estimated fish stock and impacting in seabird populations. In 2000, CCAMLR created a Catch Documentation Scheme (CDS) to identify the origin of the toothfish entering markets and whether the fish was taken under conservation regulations (CCAMLR 2001). Furthermore in 2008 the European Community (EC) adopted a regulation to prevent the importation into the EC fishery products obtained from IUU. An EC member state can refuse entry of cargo when the catch certificates and relevant documentation are absent or incomplete, does not match the fishery products, or is from an IUU black-listed vessel (MFish 2010).

2.2.3 Scientific whaling

Commercial whaling in the Ross Sea by the Japanese stopped in 1986/87 following the adoption of the International Whaling Commission (IWC) moratorium on commercial whaling. However, the following year Japan began Antarctic scientific programmes that continue to today.

The Japanese Whale Research Programme under Special permit in the Antarctic (JARPA) started its operations in 1987/88 season and continued to 2004/05. Circa 400 minke whales are caught per season, and at least one third of

the catch comes from area V, the Ross Sea and surrounding waters (IWC 1997). Around 6,800 minke whales were taken during the 18 years of JARPA's operation in the Southern Ocean. Yet, the scientific value of JARPA has been repeatedly questioned by the Antarctic community (IWC 2007).

In 2005/06, a year after JARPA finished with inconclusive and unpublished results, Japan announced the second phase of the whaling programme, known as JARPA II. The objectives for JARPA II are (IWC 2009):

- Monitoring of the Antarctic ecosystem
- Modelling competition among whale species and developing future management objectives
- Elucidation of temporal and spatial changes in stock structure
- Improving the management procedure for Antarctic minke whale stocks

JARPA II catches for 2005/06 season were 856 minke whales and 10 fin whales. For the 2007/08 season, the projection was of 850±10%, but the actual catches were much lower; 551 minke whales and no fin whales were taken. Japan anticipated that by 2008/09 the programme will be predominantly conducted within the Ross Sea (Hemmings et al. 2009). Waterhouse (2001) reports 'the direct effect on this take on the total population of minke whales in the region is currently unknown.'

The environmental risks concerned regarding this activity are many. JARPA II generates significant marine pollution from the discarding of thousands of tonnes of whale offal and other incidental wastes from whaling activities; risks of conducting maritime operations in Antarctic waters, such as refuelling or transfer of whale meat; challenging sea ice conditions and low temperatures; and a low capacity to respond to safety of management of pollution in this remote area (Hemmings et al. 2009) An example of the environmental risks associated to this operation was the explosion on the *Nisshin Maru* factory vessel in 2007, which Japan declined to report to the Antarctic Treaty Consultative Meeting (ATCM). A crew member was killed and the vessel was disabled for 10 days, left adrift in an ice exposed area of the Ross Sea (Hemmings et al. 2009).

'Scientific whaling' remains a controversial issue. The Antarctic community disagrees greatly with the methods of JARPA II and would like to see

immediate action and changes, as well as making Japan more accountable for its conduct (Hemmings et al. 2009). A joint expedition from the Australian Antarctic Division (AAD) and the New Zealand government sailed to the Ross Sea in 2010, in order to prove lethal methods are not required to study whales in the Southern Ocean. Scientists onboard successfully used techniques such as biopsies for tissue collection, satellite tracking and acoustic surveys to perform research on the whales.

2.2.4 Tourism

Tourism is the most popular non-governmental activity that takes place in the Ross Sea. The first organised cruise to the region was during the summer of 1978/1979, ten years later than for the Antarctic Peninsula. From just over a hundred passengers on the first season, tourism activities in the Ross Sea have steadily increased to reach over 700 passengers in 2009/10 (IAATO, 2010)

Tourism activities include ship-based and airborne commercial tourism, adventure tourism (i.e. yacht visits, mountaineering expeditions, polar walks) and non-governmental expeditions (eg. Greenpeace voyage). The activities carried out by cruise ship and airborne tour operators are monitored and data is compiled by IAATO, the International Association for Antarctic Tour Operators. From IAATO's data we find that in 2009/10 season, three cruise ships visited the Ross Sea region organising a total of 8 voyages (sailing from and returning to New Zealand and Australia), carrying a total of 701 passengers. The total number of tourists visiting the Ross Sea region makes only 1.9% of the overall total of tourist to Antarctica in 2009/10 season (IAATO 2010).

Ship based tourism is the primary way for tourists to travel to the Ross Sea. Tour operators organise cruises sailing from New Zealand and Australia, from late December to mid March, when sea ice has broken off allowing sailing to southern latitudes below 70ºS. The voyages take 25 to 28 days and include visits to New Zealand and Australian Sub Antarctic Islands. Prices range from US $15,000 to US$22,000 (Heritage Expeditions, 2011). The activities organized on these tours include: landing by small boats (i.e. zodiacs) in areas of special wildlife significance, walking on fast ice, helicopter flights to the Dry Valleys, visiting historic sites and monuments, and cruising through polar landscapes.

For 2009/10 season, the most visited site in the Ross sea region was Cape Evans, with over 400 passengers visiting the historic hut (IAATO 2010).

There are currently no restrictions for cruises ships or other vessels sailing in Antarctic waters to have ice-strengthening of any level. There is a potential risk of becoming stuck and crushed in sea ice, as happened to the *Southern Quest* in 1986 near Ross Island. Another delicate matter for ships is the inaccurate information of the charts for this region, with the risk of grounding or being holed by unmarked reef systems, rocks or incorrectly plotted islands. An example of the latter is the *World Discoverer* cruise ship, which in 1989 was grounded at Cape Evans (Whitehouse 2001). Damage to a ship in this fragile environment may result in significant pollution of waters and coast through the release of fuel and other contaminants.

On a positive note, cruise ships have assisted Antarctic National programmes transporting research field parties to remote locations; identifying fishing vessels at sea, or have provided rescue and support to private expeditions.

2.2.5 Private expeditions

Another form of non-governmental activity that takes place in the Ross Sea are private expeditions. The availability of satellite communication, improved quality of clothing and polar gear, and fewer places left in the world to conquer make Antarctica the ultimate destination for adventurers. The South Pole has been a popular goal over centuries and one of the best access routes is through the Ross Sea region. Private expeditions are organized for mountaineering, traversing the continent, circumnavigating of Antarctica, traversing to the South Pole, filming and diving, environmental group visits and yachts. Private expeditions are supported by sea transport, air support or land based helicopter. Before the Madrid Protocol (1991), many have used sled dog teams.

The issues concerning private expeditions taking place in remote and isolated locations in the Antarctic, as well as the logistics of safety, contingency plans and the management of waste and pollutants is similar to those of commercial tourism operations. Although the environmental disturbance could be less than minor due to the smaller scale operation of these expeditions, it

should be considered that there is a larger risk for injuries and potential life threatening situations that will demand immediate evacuation, waste transport, schedule delays or route detours due to weather conditions, among others. These risks demand that the expedition to be self sufficient, have good insurance cover and a support team. In some cases, these may result in great financial losses for the organisers. Some countries, like the United States, do not support or offer services to private expeditions in Antarctica (NSF - USAP 2010)

Both, commercial tourism and private expeditions to the Antarctic fall under the provisions of the Antarctic Treaty, its recommendation and protocols. Both should submit environmental impact assessments to their national authorities before the activities are carried out. Some countries, like New Zealand, appoint government observers onboard cruise ships operating in the Ross Sea region, to ensure compliance with Antarctic Treaty regulations.

3. MARINE PROTECTED AREAS

Since the 1990s, marine protected areas have been enjoying increased popularity as a management tool for conserving marine biodiversity and fragile areas.

3.1 What is a Marine Protected Area?

In essence, a marine protected area (MPA) is a catch-all phrase for wide variety of approaches to marine place-based conservation and management. In practice, a MPA represents a defined geographic area where natural and/or cultural resources are given greater protection than in surrounding waters (Kim 2010). MPAs are frequently assumed to be no-take or no-go zones, but in reality there are many other possible levels of protection, such as seasonal closures or restrictions on fishing methods or depths.

However in the past ten years, there has been increasing global recognition that no-take MPAs can have very important benefits for the conservation of ocean ecosystems (WCPA/IUCN 2007). Between 2002 and 2004, the World Summit on Sustainable Development, the IUCN World Commission on Protected Areas, the Convention on Biological Diversity and the G8 group of Nations all called for the establishment of a global system of MPA networks by 2012 (WCPA/IUCN 2007, Corrigan & Kershaw 2008); in order to protect marine biodiversity and manage resources effectively, it is believed we must establish representative MPA networks across 20 to 30% of our seas and oceans (WCPA/IUCN 2007, Corrigan & Kershaw 2008).

A set of seven scientific criteria for identifying marine areas suitable for protection was developed at the Convention on Biological Diversity's Ninth Conference of Parties in May 2008 (CBD 2008). These are outlined in Table 1.

Table 1. Seven criteria identified by the Convention on Biological Diversity as requiring consideration when designating marine protected areas, including open-ocean waters and deep-sea habitats. Adapted from CBD (2008).

Criteria	Definition	Rationale
Uniqueness or rarity	Area contains either (i) unique ("the only one of its kind"), rare (occurs only in few locations) or endemic species, populations or communities, and/or (ii) unique, rare or distinct, habitats or ecosystems; and/or (iii) unique or unusual geomorphological or oceanographic features	Irreplaceable loss would mean the probable permanent disappearance of diversity or a feature, or reduction of the diversity at any level.
Special importance for life history stages of species	Areas that are required for a population to survive and thrive.	Various biotic and abiotic conditions coupled with species-specific physiological constraints and preferences tend to make some parts of marine regions more suitable to particular life-stages and functions than other parts.
Importance for threatened, endangered or declining species or habitats	Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species.	To ensure the restoration and recovery of such species and habitats.
Vulnerability, fragility, sensitivity or slow recovery	Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.	The criteria indicate the degree of risk that will be incurred if human activities or natural events in the area or component cannot be managed effectively, or are pursued at an unsustainable rate.
Biological productivity	Area containing species, populations or communities with comparatively higher natural biological productivity.	Important role in fuelling ecosystems and increasing the growth rates of organisms and their capacity for reproduction
Biological diversity	Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.	Important for evolution and maintaining the resilience of marine species and ecosystems
Naturalness	Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.	To protect areas with near natural structure, processes and functions; to maintain these areas as reference sites; to safeguard and enhance ecosystem resilience

Of particular interest in regards to a proposed MPA for the Ross Sea region is the literature surrounding the implementation of MPAs for areas of ocean beyond national jurisdiction – the waters outside of any country's 200-nautical mile exclusive economic zone (EEZ).

3.2 Marine Protected Areas in the High Seas

The areas of ocean that lie beyond limits of national jurisdiction – the 'high seas' – are vulnerable to human exploitation and are currently grossly underrepresented in terms of protected areas when compared to near-shore environments. The high seas cover nearly 50% of the earth's surface and account for 90% of global biomass, yet in 2008 only 0.51% of this area had been granted some form of protected area status. As such there has been increased interest within the global conservation community to increase measures to protect these areas and the important biodiversity that can be found there (Corrigan & Kershaw 2008). In 2004, the UN General Assembly created a working group "to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction" (Kim 2010). Historically there has been no single international body charged with the creation and regulation of high seas MPAs (HSMPAs), despite the duty in the United Nations Law of the Sea Convention (UNCLOS) to protect and preserve rare or fragile ecosystems as well as habitat of depleted, threatened or endangered species (Hart 2008).

A recurring comment in the MPA literature is the need for a precautionary approach in MPA implementation. The World Commission on Protected Areas (WCPA – administered by the IUCN) believes MPA designers should be basing their decisions on the best information currently available, rather than delaying the process of implementing MPAs. The United Nations Environment Programme (UNEP) also supports this idea; they suggest new data gathered during or after the planning process can be applied through an 'adaptive management' approach (WCPA/IUCN 2007, Corrigan & Kershaw 2008). Ongoing research, monitoring and assessment is essential for managers to determine if progress is being made toward the objective and goals of a MPA; monitoring is crucial from the onset and should also include sites beyond the MPA boundaries that act as controls (WCPA/IUCN2007). The UNEP comments that while management of MPAs in

near-shore environments is challenging in its own right, this "should not prevent the advancement of protecting high seas biodiversity" (Corrigan & Kershaw 2008, p. 5). Further, UNEP suggest HSMPA pilot studies and demonstration areas should be established to:

1. secure protection for priority high diversity areas as an initial contribution to the global marine protected areas network, and
2. to start learning from practical experience how HSMPAs can be managed and compliance secured.

However it is noted that the creation of HSMPAs in the present political and scientific setting requires a balance between increasing the scientific rigour associated with HSMPA proposals, and taking precautionary action regarding human activities on the high seas where their environmental impacts are not yet known (Corrigan & Kershaw 2008).

3.2.1 Southern Ocean case study: South Orkney MPA

In November 2009, CCAMLR announced a no-take MPA was to be created for an area south of the South Orkney Islands, a decision which came into force in May 2010. These islands are located in the general area of the Antarctic Peninsula, in West Antarctica. The protected zone is 94,000km^2 and approximately rectangular in shape. Dr Phil Trathan, who co-led much of the scientific work behind the MPA proposal commented that "The South Orkneys MPA … will help conserve important ecosystem processes, vulnerable areas, and create reference sites that can be used to make scientific comparisons between fished areas and no-take areas. Such networks will become increasingly important as climate change impacts become increasingly evident in the future." (Trathan 2010). The South Orkney MPA was widely lauded as the first in the high seas, and the first step toward a network of 11 MPAs for the Southern Ocean (WWF 2009). The Ross Sea has been identified as one of these 11 areas worthy of protection.

4. PROPOSING A MARINE PROTECTED AREA FOR THE ROSS SEA

Research by Halpern et al. (2008) reviewing the status of global oceans demonstrated that no area of the ocean has escaped human impact. However the Ross Sea has been identified as one area where impacts are less extensive and the unique characteristics of the area suggest protection is a worthwhile goal for ongoing management of the region (ASOC 2010). At the 2008 World Conservation Congress, the IUCN-WCPA and Marine Conservation Biology Institute (MCBI, a NGO) released a list of ten "High Seas Gems", examples of important high seas locations with features meriting protection; the Ross Sea was included in its entirety (Corrigan & Kershaw 2008). Indeed, as of October 2008, the IUCN, WWF, ASOC, Fundación Vida Silvestre Argentina, and Greenpeace had all made independent and/or collaborative proposals for a HSMPA in the Ross Sea or Pacific Antarctic Ridge area (Corrigan & Kershaw 2008). Some of the features of the Ross Sea that suggest it requires protection are outlined in Table 2.

Table 2.How the Ross Sea region meets the seven criteria identified by the Convention on Biological Diversity as requiring consideration when designating marine protected areas. For the definition and rationale behind the criteria, see Table 1. Adapted from CBD (2008) and ASOC (2010).

Criteria	How the Ross Sea complies
Uniqueness or rarity	Least impacted continental shelf worldwide; this area has been identified as likely to be the last pack-ice ecosystem to exist as climate change progresses.
Special importance for life history stages of species	Recognised spawning and sub-adult toothfish habitat.
Importance for threatened, endangered or declining species or habitats	Benthic biodiversity hotspot; also home to large proportions of penguins and southern hemisphere seal species; these species also show genetic uniqueness compared with other populations.
Vulnerability, fragility, sensitivity or slow recovery	Polar species are typically slow-growing and long-lived and so vulnerable to disturbance and exploitation.
Biological productivity	Most biologically productive region in entire Southern Ocean.
Biological diversity	>500 species first described in Ross Sea; several new species found on recent expeditions for CAML.
Naturalness	The most pristine pack-ice ecosystem on earth.

In addition to these characteristics, the Ross Sea ecosystem is also of immense value as a long-term monitoring site for assessing biological responses to climate change. The Ross Sea is already the location of some of the longest running biological research programmes, which study the seals, penguins, toothfish and benthos of the area (ASOC 2010). Interfering with the system now at a level greater than what is currently happening will jeopardise the usefulness of these long-term datasets, by introducing outside pressures to the system.

While it has been noted previously that there is no one global governance unit that can create and administer high seas MPAs, much of the Southern Ocean is unique in that its management falls under the auspices of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) and the Antarctic Treat System (ATS).

4.1 The role of CCAMLR in managing resources in the Southern Ocean

In 1982, the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) came into force as part of the Antarctic Treaty System. CCAMLR was established in response to concerns that an increase in krill catches in the Southern Ocean could adversely impact krill populations and other marine life for example, birds, fish and seals dependent on krill for food (CCAMLR, 2001).

The aim of the Convention is to conserve marine life of the Southern Ocean, however this does not exclude harvesting carried out in a rational manner. Nonetheless, the principles of Article II of the Convention require that:

> (i) exploited populations shall not be allowed to fall below a level close to that which ensures their greatest net annual increase;
>
> (ii) ecological relationships between harvested, dependent and related species shall be maintained and depleted populations shall be restored to the levels defined in (i); and
>
> (iii) risks of changes to the marine ecosystem that are not potentially reversible over two or three decades shall be prevented or minimised (CCAMLR 1982).

The Convention applies to all marine living resources (except seals south of 60°S and whales in general). The northern boundary is delineated by the mean position of the Antarctic Polar Front enabling it to follow the physical and biological boundaries of the Antarctic. The Convention Area is divided into three sectors (Atlantic Ocean, Indian Ocean and Pacific Ocean), which for statistical purposes are termed Statistical Areas 48, 58 and 88 – refer Figure 2. (CCAMLR, 2000). Note that the Ross Sea falls into both areas 88.1 and 88.2.

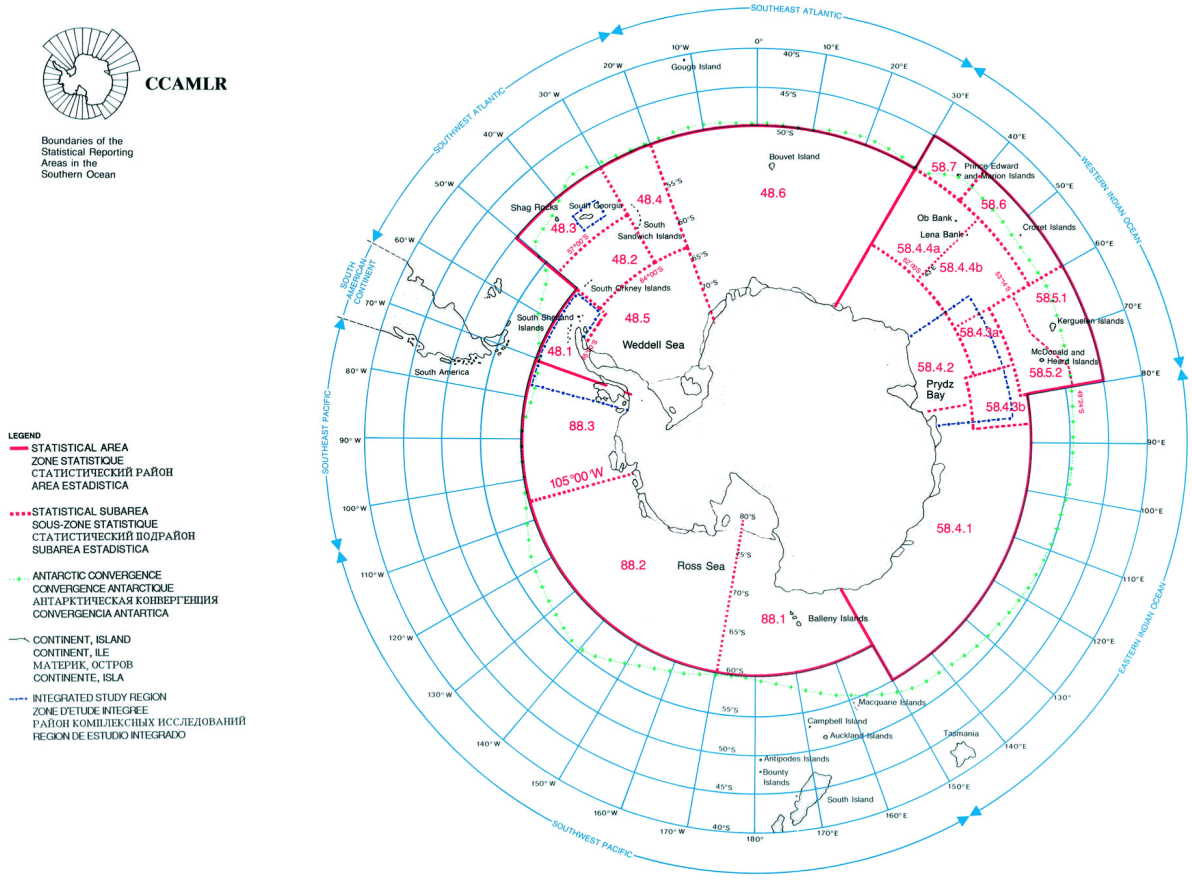

Figure 2. Boundaries of statistical reporting areas of the Southern Ocean (CCAMLR, 2010)

4.1.1 The precautionary approach for catch limits

CCAMLR implements a 'precautionary' approach when determining catch limits for each statistical area and subarea in order to minimise risks associated with the harvesting of Antarctic marine living resources. This means CCAMLR collects all available data and determines the potential effect of uncertainties and gaps in the data before making decisions on catch limits (CCAMLR, 2001). The aim of this

approach is to make timely decisions that minimise the risk of long-term adverse effects, rather than delaying decisions until all necessary data is available.

CCAMLR also follows an 'ecosystem' approach when making decisions on catch limits. In particular, CCAMLR monitors selected species that depend on, or are related to, commercial target species and fisheries. The CCAMLR Ecosystem Monitoring Program (CEMP) was established to monitor and record fishing of marine life in and around Antarctica. The goals of the CEMP are to:

> (i) Detect and record significant changes in critical components of the marine ecosystem within the Convention Area, to serve as a basis for the conservation of Antarctic marine living resources; and
> (ii) Distinguish between changes due to harvesting of commercial species and changes due to environmental variability, both physical and biological (CCAMLR, 2001).

The species being monitored have been selected from:

- Key prey species - these have some potential for harvesting and currently include krill, Antarctic silverfish and early life-stages of fish; and
- Important predator species - these feed mainly on key prey species (at this stage particularly krill), have a wide geographical distribution, and occupy an important position in the ecosystem. They currently include Antarctic fur and crab eater seals as well as Adélie, chinstrap, gentoo and macaroni penguins, Antarctic and cape petrels, and black-browed albatross (CCAMLR 2001).

4.2 New Zealand's Ross Sea Strategy

In 2006, the New Zealand Government developed the New Zealand Strategy for the Future Management of the Marine Living Resources and Biodiversity of the Ross Sea. The Ross Sea Strategy states New Zealand should ensure there is a balance between sustainable harvesting, according to CCAMLR conservation principles, and marine protection to safeguard the long-term ecological viability and biological diversity of the Ross Sea (MFAT, 2010).

The Ross Sea Strategy states that the intermediate outcomes include:

- Improved protection of the region's environment;
- Better fisheries management within CCAMLR;
- Successful deterrence and reduction of illegal, unreported and unregulated (IUU) fishing;
- Enhancement of New Zealand's influence (supported by an effective New Zealand presence in the Ross Sea); and
- Improved effectiveness of the Antarctic Treaty System (MFAT, 2010).

To achieve these outcomes, the Ross Sea Strategy states New Zealand must:

- Increase its contribution to Ross Sea marine research and ecosystem monitoring;
- Improve CCAMLR's fisheries management through development of a medium term management plan for the Ross Sea fishery;
- Promote the establishment of a catch allocation mechanism to Members;
- Promote the establishment of MPAs on the high seas in the CCAMLR Area; and
- Combat IUU fishing in the Southern Ocean and the Ross Sea

(MFAT, 2010)

4.3 Applying a precautionary management regime to the Ross Sea

With a total area of 647,000km^2, the Ross Sea makes up just two percent of the Southern Ocean, and is entirely covered by sea ice during the winter. A large part of the marine ecosystem is covered by the ice shelf and pack ice, meaning the area where fishing or other extractive activities can occur is relatively small (Riffenburgh 2007). In recognition of the unique physical and biological attributes of the region, and despite New Zealand's current stance on continuing exploitation (see previous section) the present authors suggest that long term, some form of protection is required for the Ross Sea. Suggestions are outlined below.

4.3.1 Plan A: The entire Ross Sea becomes a no take zone

Plan A is to ban all extractive resource use in the Ross Sea indefinitely. This includes fishing, bioprospecting, whaling and other potential extractive activities. By placing a ban on extracting resources, the Ross Sea region will remain in its near-pristine state and any damage to the ecosystem or the environment will have a chance restore itself. Additionally, the Ross Sea may become a nursery zone or a potential source of toothfish for other areas and scientists will have the chance to research the lifecycle of the Antarctic toothfish, gaining valuable information about spawning and breeding grounds, juvenile stages, and migration. A further benefit is the lessened risk of environmental damage; there is a possibility that fishing and whaling vessels may run aground, sink, or spill oil into the Ross Sea, however, this risk is lessened if fishing and whaling vessels are excluded from the area.

However, placing an indefinite ban on resource extraction in the Ross Sea does not come without difficulties. The Antarctic toothfish fishery in the Ross Sea is worth $20 million to New Zealand alone (Gibson 2011). A direct result of a ban on extracting resources is the economic loss to the countries that extract from the region. Economic loss will also be coupled with the costs of ongoing enforcement of the region and backlash from the fishing and whaling industries. Furthermore, fishing effort will mostly likely be transferred elsewhere, possibly straining or further depleting other fish stocks in the Southern Ocean. Finally, CCAMLR will be required to rezone areas 88.1 and 88.2 in their protocol as these would no longer be considered fishing grounds.

4.3.2 Plan B: Part/s of the Ross Sea becomes a no take zone/s

Plan B proposes to establish one or more no take zone/s, in the Ross Sea region. Establishing one or a number of MPAs would create regions for research into the Antarctic toothfish and climate change, unaffected by human activities. There is also potential to protect critical areas of the Ross Sea, for example the breeding grounds of the Antarctic toothfish. However, as little is known about this species so plan B would require some initial data or research to identify these critical areas. The MPAs would be indefinite yet flexible. As data is gathered about the

Ross Sea and the resulting ecosystem, the MPAs could be moved or relocated to the essential areas.

One could argue that the remapping of the marine protected area(s) and the rezoning of CCAMLR fishing areas to exclude the Ross Sea could be troublesome. Some economic loss is also to be expected, however, this may be counterbalanced by some resource extraction in the region and the benefits provided by nursery zones to the fishery. Protecting a handful of small areas might be more cost effective, requiring fewer resources to police, lessened public outcry, and the opportunity for cooperative reinforcement from resource extractors and tourism operators.

4.3.3 Plan C: The entire Ross Sea becomes a no take zone for 30 years

Finally, plan C – the preferred plan (also see Appendix). Plan C involves placing a moratorium on resource extraction (fishing, whaling, bioprospecting) for a period of 30 years with the possibility of fishing being allowed to resume once the 30 year period ends. Due to the near-pristine state of the Ross Sea it is a great platform for scientific research into climate change effects, the operation of marine ecosystems prior to human impacts, and for studying the Antarctic toothfish – a species we know very little about. Placing a moratorium on the Ross Sea would allow scientists to research the lifecycle of the Antarctic toothfish. This holds many benefits – scientists and fishermen alike would gain an understanding of the number of toothfish available, the breeding and spawning grounds, and the age of maturity. Such information will allow for accurate catch limits to be set (it could be higher than it currently is), and special areas including breeding grounds to be protected which in turn would keep the Antarctic toothfish populations viable for fishing.

A moratorium in the Ross Sea also holds other benefits – a near-pristine environment will be protected, depleted stocks of fish and mammals will have a chance to recover from both past and previous exploitation, and damage to the environment from oil spills or boat wrecks will be lessened. The main idea of the moratorium is that it provides time for research into the Antarctic toothfish lifecycle and if the data shows that this population can be sustainably harvested after 30 years the moratorium can be lifted in certain areas and for certain

months of the year. Plan C offers the possibility of resource extraction in the future if the data shows that this activity can be performed sustainably.

While the benefits are numerous, there are some negative aspects to plan C. The most obvious is the economic loss from no resource extraction in the next 30 years. Fishing effort would move elsewhere and fishermen would most likely need to fund research expeditions to look for new fishing grounds. Perhaps the biggest issue is the ongoing costs of policing the area and maintaining the moratorium for the next 30 years.

There are some more general considerations to take into account for the three plans:

- Toothfish are a luxury food item, typically served in high-end restaurants. In removing a large fishing ground, toothfish becomes harder to get and therefore more valuable. Consumer demand could potentially increase if the fish is seen as a status symbol. An education campaign to raise public awareness about where toothfish come from would be beneficial. Toothfish would inevitably become less desirable if people knew the fishery could be harming penguins, seals and so on.
- Food miles and carbon credits – it would make more economic sense to fish for toothfish in areas closer to the markets in the United States and Europe. If the Ross Sea is being fished because Patagonian toothfish stocks are collapsing, then there is a wider issue that needs addressing.
- In the case of plan C there are several incentives that can be offered to resource extractors during the 30-year intervention period:
    - permits to fish elsewhere, possibly within the New Zealand EEZ.
    - resource extractors that help with research and/or enforcement could be offered first opportunity to extract/apply for a permit when/if the moratorium is lifted.
- The moratorium could be extended for an additional length of time in the event that the data is incomplete or shows that resources in the Ross Sea cannot be sustainably harvested.

4.4 Enforcing a 'no take' zone in the Ross Sea

'Compliance' is when people voluntarily accept and act according to the rules and regulations set up to benefit a protected area. 'Enforcement' is the action taken against people who fail to adhere to the rules. It is an important consideration of MPA planning that it must be more profitable and preferable for the public to comply with the MPA regulations than to not comply, otherwise the rules are meaningless and the MPA will not be an effective management tool (WCPA/IUCN 2007). In the event of non-compliance, there are a number of enforcement options available.

4.4.1 Current surveillance and enforcement by New Zealand

The Royal New Zealand Navy (RNZN) has received two new Offshore Patrol Vessels (OPVs) HMNZS *Otago* and *Wellington* under 'Project Protector'- a project run by the RNZN to conduct tasks for and with the NZDF, New Zealand Customs, the Department of Conservation, Ministry of Agriculture and Forestry, Ministry of Foreign Affairs and Trade, Ministry of Fisheries, Maritime New Zealand and the New Zealand Police in waters including the Southern Ocean (NZMD 2011, RNZN 2011).

The OPVs can go further offshore, stay at sea longer, and conduct more challenging operations than the Inshore Patrol Vessels, and will enable the RNZN to conduct patrol and surveillance operations in the Southern Ocean. The OPV's are capable of many roles including maritime patrol, surveillance and response. They have the ability to conduct helicopter operations using a Seasprite helicopter, boarding operations using the ships Rigid Hull Inflatable Boats, or Military Support Operations with embarked forces. The OPV's have strengthened hulls which enable them to enter southern waters where ice may be encountered. They are not designed as ice-breakers or to enter Antarctic ice-packs, but have the range and capability to undertake patrols in the Southern Ccean where ice may be encountered (RNZN, 2011).

The Royal New Zealand Air Force (RNZAF) conducts regular over-flights of the Southern Ocean as part of its surveillance of New Zealand's Exclusive Economic Zone (EEZ) and to seek out IUU fishing activity in the Southern Ocean. Aerial surveys are more cost effective when coverage includes a network of

MPAs rather than a single area (WCPA/IUCN 2007). Currently these flights depart from Dunedin on 11 hour missions. In the past the RNZAF has considered stationing a team at Scott Base each summer to conduct surveillance flights over the Ross Sea and Southern Ocean (NZ Herald 2005). Both the Royal Australian Airforce and New Zealand Defence Force will in the future consider purchasing unmanned aerial vehicles (UAV), in particular the Global Hawk, as a replacement for their aging maritime planes for surveillance over territorial waters and the monitoring of illegal fishing in the Southern Ocean (NZ Herald 2009, The Australian 2009). The Global Hawk has a top speed of 800 km/h, cruising speed of 350 km/h, flies at an altitude of 65,000 feet and stay aloft for 30 hours, providing high resolution, and near-real time imagery of large geographic areas (Northrop Grumman 2011).

4.4.2 Opportunities for cooperative enforcement

Currently, Australia, France, New Zealand, the United Kingdom and South Africa cooperate through CCAMLR to combat IUU fishing in the Southern Ocean. However, there is no formal agreement between all five countries regarding the pooling of resources to counter IUU fishing. There is the potential for these countries and others to formalise an agreement to cooperate in the enforcement of a Ross Sea MPA in addition to combating IUU fishing in the Southern Ocean. Potentially, a Joint Resources Pool could be established with nations sharing vessels and fisheries officers and conducting joint patrols, creating a kind of 'Antarctic Coastguard'. The benefits of this would be more effective enforcement of CCAMLR and the reduction in IUU fishing in the Ross Sea and potentially the entire Southern Ocean.

The Australian Government agreement with the French Government to strengthen cooperative patrols in the Southern Ocean could be the basis for such a formal agreement. The Australia-France Cooperative Enforcement Agreement allows joint Australian and French patrols to enforce each other's fishing laws in their respective exclusive economic zones (EEZs) and territorial seas in the Southern Ocean (Australian Minister for Foreign Affairs, 2011). The cooperative enforcement measures include the boarding, inspection, hot pursuit, apprehension, seizure and investigation of fishing vessels that are believed to

have breached fisheries laws. The French patrols will have Australian Fisheries Management Authority and Customs officers aboard their ships, while the Australian patrol boat, *Ocean Protector*, has French officials on board- the exchange of personnel is necessary to apply and enforce each country's laws. For instance, for Australian vessels to enforce French fisheries laws in French waters a French officer must be aboard and vice versa when French vessels are in Australian waters (Australian Minister for Foreign Affairs, 2011)

5. FINAL RECOMMENDATIONS & CONCLUSION

The Ross Sea is a unique region of the Southern Ocean and the Antarctic, not just for its natural and physical characteristics but also for its unparalleled wildlife.

Comprehensive protection for the Ross Sea would deliver a wide range of ecosystem benefits that further the key values of the Antarctic Treaty, the Environmental Protocol and CCAMLR. For decades the Antarctic continent has been managed as a natural reserve devoted to peace and science. The time has come to extend this level of care beyond the continent and into the surrounding ocean. Maintaining the unique living laboratory of the Ross Sea would act as tangible example of forward thinking marine management for other high seas locations in the Southern Ocean and beyond.

Designating the Ross Sea a marine protected area will give the ecosystem a chance to recover from the past and present impacts of fishing/whaling while providing the ecosystem with a better chance of adapting to the challenges presented by future climate change. If we truly value the unique features of the Ross Sea, we must act now to preserve it.

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7. REFERENCES

Ainley, D. (2010a) In the midst of marine collapse will we save our last ocean? An interview with David Ainley. Available online: http://news.mongabay.com/2010/0705-hance_ainley.html.

Ainley, D. (2010b) A history of exploitation of the Ross Sea, Antarctica. *Polar Record* 46(03), 222-232.

Ainley, D.G. & Blight, L.K. (2009) Ecological repercussions of historical fish extraction from the Southern Ocean. *Fish and Fisheries* 10, 13- 38 .

ASOC (2009) A Ross Sea MPA: Preservation for science. [Online] ATCM 13, CEP. IP 48 rev. 1 [Accessed 11th January 2011].

ASOC. (2010) The case for inclusion of the Ross Sea continental shelf and slope in a Southern Ocean network of marine reserves. Presented to the XXXIII Antarctic Treaty Consultative Meeting, May 3-14 2010.

Australian Minister for Foreign Affairs (2011). Australia and France send strong message to illegal fishing operators. [Online] http://foreignminister.gov.au/releases/2011/kr_mr_110107.html [Accessed 18th January 2011].

Blight, L.K. et al. (2010) 'Fishing for data in the Ross Sea'. *Science* 330(6009), 1316

CCAMLR (1982) Convention on the Conservation of Antarctic Marine Living Resources. [Online] http://www.ccamlr.org/pu/e/e_pubs/bd/pt1.pdf [Accessed 12th January 2011].

CCAMLR (2000) CCAMLR's management of the Antarctic. [Online] http://www.ccamlr.org/pu/E/e_pubs/am/man-ant/toc.htm [Accessed 13th January 2011].

CCAMLR (2001) Understanding CCAMLR's approach to management. [Online] http://www.ccamlr.org/pu/E/e_pubs/am/toc.htm [Accessed 13th January 2011].

CCAMLR (2010) Vessels licensed to harvest in the convention area in the 2010/2011 intersessional period. [Online] http://www.ccamlr.org/pu/e/sc/fish-monit/vess-licensed.htm [Accessed 17th January 2011].

Cessford, G. & Dingwall, P. (1998) Research on shipborne tourism to the Ross Sea region and the New Zealand sub-Antarctic islands. *Polar Record*, 34 (189), 99-106

Convention on Biological Diversity (2008) Marine and Coastal Biodiversity, COP9 Decision IX/20 (Annex 1-3), Bonn, May 19-30 2008.

Corrigan, C. & Kershaw, F. (2008) Working toward High Seas Marine Protected Areas: an Assessment of Progress Made and Recommendations for Collaboration. UNEPWCMC, Cambridge, UK.

Dorey, C. & Lütkebohle, T. (2010) Defending the last ocean: how seafood markets can help save Antarctica's Ross Sea. Ottho Heldringstraat 5, The Netherlands.

Eastman, J.T. (2005) The nature of the diversity of Antarctic fishes. *Polar Biology* 28, 93-107

Gibson, E. (2011) Forfeit $20 million to save Ross Sea, NZ urged. New Zealand Herald [Online] http://www.nzherald.co.nz/environment/news/article.cfm?c_id=39&objectid=10609427 [Accessed 16th January 2011].

Halpern, B.S., Walbridge, S., Selkow, K.A., Kappel, C.V., Micheli, F., D'Agrosa, C., Bruno, J.F., *et al* (2008) A Global Map of Human Impact on Marine Ecosystems. *Science* 319, 948-952.

Hart, S. (2008) Elements of a possible implementation agreement to UNCLOS for the Conservation of Sustainable Use of Marine Biodiversity in Areas beyond National Jurisdiction, IUCN, Gland, Switzerland.

Hemmings, A.D., Kaye, S., Mossop, J., Rothwell, D.R., Stephens, T. & Triggs, G. (2009) Japan's 'Scientific' whaling program and the Antarctic Treaty system. Independent Panel of Legal and Policy Experts. Canberra

Heritage Expeditions. (2011) The Ross Sea departures [Online] http://heritage-expeditions.com/trip/the-ross-sea-1# [Accessed 17th January 2011].

IAATO (2010) Tourism statistics: 2009-2010 Tourism summary. [Online] http://www.iaato.org/tourism_stats.html [Accessed 17th January 2011].

IWC (1997) Report of the scientific Committee. *Report of the International Whaling Commission* 47, 59 - 258

IWC (2007) The environment and whale stocks. [Online] http://www.iwcoffice.org/conservation/environment.htm#sower [Accessed 17th January 2011].

IWC (2009) Scientific permit whaling: Antarctic (2) – JARPA II [Online] http://www.iwcoffice.org/conservation/permits.htm#jarpa [Accessed 18th January 2011].

Kim, E. (2010) High seas marine protected areas & United Nations Working Group on Marine Biodiversity Beyond National Jurisdiction. Talk presented to the Environmental Law Institute, December 16 2010. Slides available online at: http://www.eli.org/pdf/seminars/12.16.10dc/kim.pdf

Ministry of Fisheries 2010. Fishing in the Ross Sea[Online] http://www.fish.govt.nz/en-nz/International/Fishing+in+the+Ross+Sea.htm [Accessed 17th January 2011].

Ministry of Foreign Affairs and Trade (2010) Ross Sea Strategy. [Online] http://www.mfat.govt.nz/Foreign-Relations/Antarctica/1-New-Zealand [Accessed 12th January 2011].

National Science Foundation (2008) U.S. Policy in Private Expeditions to Antarctica [Online] http://www.nsf.gov/od/opp/antarct/ngo_policy.jsp [Accessed 18th January 2011].

New Zealand Herald (2005) Fish poachers' patrol may stay in Antarctic [Online] http://www.nzherald.co.nz/orion-new-zealand-limited/news/article.cfm?o_id=146&objectid=10334498 [Accessed 18th January 2011].

New Zealand Herald (2009) Spy drones on NZ defense wish list. [Online] http://www.nzherald.co.nz/new-zealand/news/article.cfm?l_id=71&objectid=10600341 [Accessed 18th January 2011].

New Zealand Ministry of Defence (2011) Project Protector. [Online] http://www.defence.govt.nz/acquisitions-tenders/current-acquisition-projects/project-protector.html [Accessed 18th January 2011].

Northrop Grumman (2011) RQ-4 Block 20 Global Hawk. [Online] http://www.as.northropgrumman.com/products/ghrq4b/assets/GH_Brochure.pdf [Accessed 17th January 2011].

Pitman, R.L., Perryman, W.L., Leroi, D. & Eilers, E. (2007) A dwarf form of killer whale in Antarctica. *Journal of Mammalogy* 88, 43-48.

Riffenburgh, B. (ed.) (2007) *Encyclopedia of the Antarctic*, Volume 2. Taylor and Francis Group, New York.

Royal New Zealand Navy (2011) Visit the fleet. [Online] http://www.navy.mil.nz/visit-the-fleet/default.htm [Accessed 17th January 2011].

Smith, W.O., Ainley, D.G. and Cattaneo-Vietti, R. (2007) Trophic interactions within the Ross Sea continental shelf ecosystem. *Philosophical Transactions of the Royal Society B* 362, 95-111.

The Australian (2009) Global Hawk still in sights for RAAF. [Online] http://www.theaustralian.com.au/national-affairs/defence/global-hawk-still-in-sights/story-e6frg8yo-1111119165277 [Accessed 18th January 2011].

Trathan, P. (2009) News Story - South Orkneys Marine Protected Area. British Antarctic Survey Press Release. [Online] http://www.antarctica.ac.uk/about_bas/news/news_story.php?id=1054. [Accessed 09th January 2011].

Waterhouse, E. (2001) *Ross Sea Region 2001: A State of the Environment Report for the Ross Sea region of Antarctica*. New Zealand Antarctic Institute.

WCPA/IUCN (2007) Establishing networks of marine protected areas: A guide for developing national and regional capacity for building MPA networks. Non-technical summary report.

WWF (2009) 'Southern Ocean protected area to shield marine region more diverse than Galapagos' [Online] http://wwf.panda.org/?181481/Southern-Ocean-protected-area-to-shield-marine-region-more-diverse-than-Galapagos [Accessed 11th January 2011].

APPENDIX

A survey of preferred Ross Sea Management plans, as chosen by audience members at the PCAS syndicate presentations, January 20 2011.

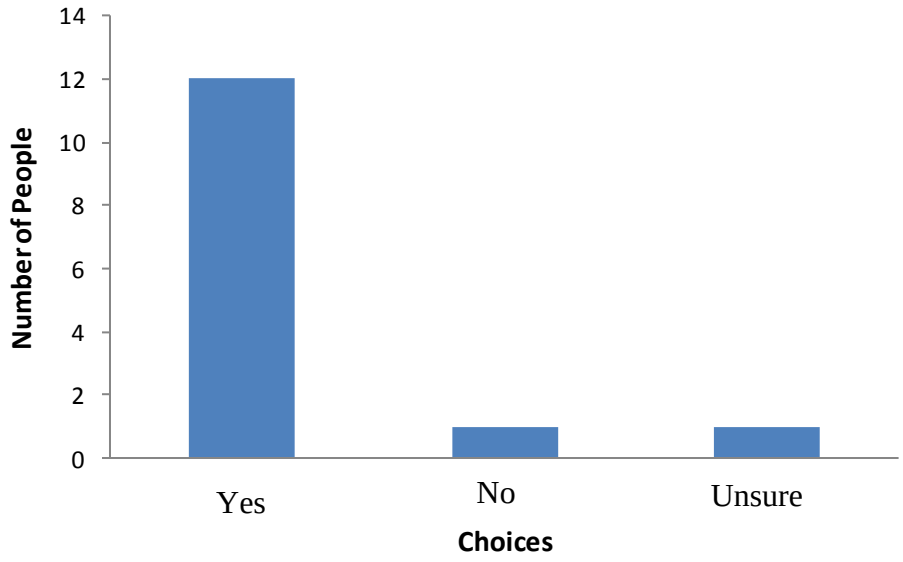

Figure 3. The number of people who chose Yes, No, or Unsure/Partial when asked if they though the Ross Sea should have some form of MPA in place.

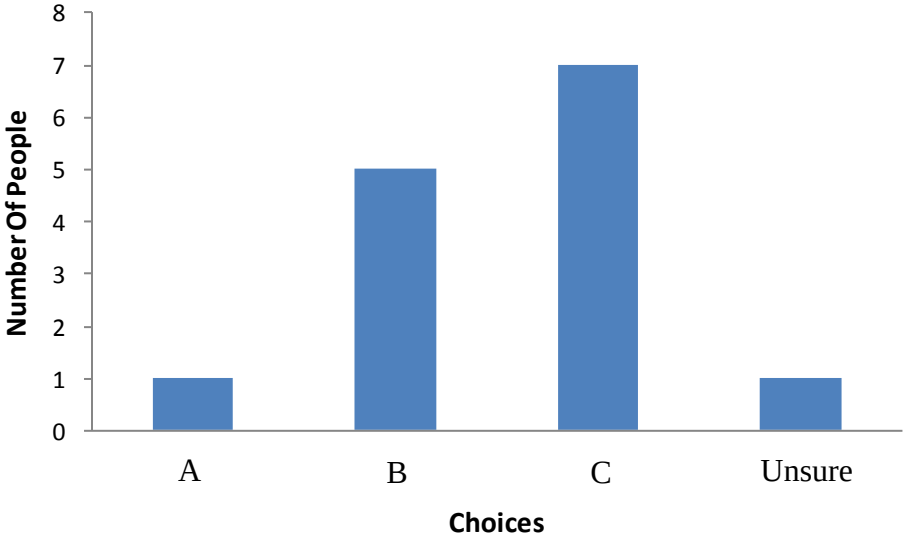

Figure 4. Number of people who chose Plan A, B, C, or Unsure when asked which of our possible management options they preferred for the Ross Sea.